FINAL REPORT
TRACK/TRAIN DYNAMICS
PHASE IX
TP 4363 E

Library and Information Centre/
Centre de Documentation (GSLA)
RECEIVED - REÇU LE
MAY 31 1983
Transport Canada / Transports Canada

Prepared for
Transport Canada
Transportation Development Centre

Canadian National Railways
CN Rail Research
March 1983

REPORT DOCUMENTATION FORM

1. Transport Canada Report No.	2. TDC Project No.	3. Recipient's Catalogue No.
TP 4363E	4567	

4. Title and Subtitle	5. Report Date
Final Report Track/Train Dynamics - Phase IX	MARCH 31, 1983
	6. Performing Organization Report No.

7. Author(s)	8. Transport Canada File No.
R.P. Rennie	D1465-108-6-9

9. Performing Organization Name and Address	10. DSS File No.
CN Rail Research 935 de LaGauchetière Street West Montreal, Quebec H3C 3N4	11SD.T8200-1-1572
	11. DSS or Transport Canada Contract No.
	OSD81-00186

12. Sponsoring Agency Name and Address		13. Type of Report and Period Covered
Transportation Development Centre(TDC) 1000 Sherbrooke Street West Suite 2421 Montreal, Quebec H3A 2R3	CN Rail Research 935 de LaGauchetière Montreal, Quebec H3C 3N4	Apr. 1/82 - March 31/83
		14. Sponsoring Agency Code
		TDC 4567

15. Supplementary Notes	16. TDC Project Officer
	D.W. Dibble

17. Abstract

This report describes the research carried out on TDC/CN contract OSD81-00186 over the period 1 April 1982 to 31 March 1983. The report deals with continuing laboratory and field research to improve the performance characteristics of concrete ties, to develop an effective and efficient method of determining optimum ballast thickness, to develop improved techniques for controlling thermal effects in continuous welded rail, to develop a prototype system for continuous measurement of track modulus and to improve the utilization of rail lubrication.

18. Key Words	19. Distribution Statement
Research and Development, Rail, Track/ Train Dynamics, Ballast, Subballast, Track, Concrete, Ties, Stress, Fastener	Limited number of copies available from TDC

20. Security Classification (of this report)	21. Security Classification (of this page)	22. No. of Pages	23. Price
Unclassified	Unclassified		--

FORMULE DE DOCUMENTATION POUR RAPPORT

1. N° du rapport Transports Canada	2. N° de l'étude — CDT	3. N° de catalogue du destinataire
TP 4363E	4567	

4. Titre et sous-titre	5. Date du rapport
Final Report Track/Train Dynamics - Phase IX	31 mars 1983
	6. N° du rapport de l'organisme exécutant

7. Auteur(s)	8. N° de dossier Transports Canada
R.P. Rennie	D1465-108-6-9

9. Nom et adresse de l'organisme exécutant	10. N° de dossier — ASC
CN Rail Research 935 o., rue de LaGauchetière Montréal, Québec H3C 3N4	11SD.T8200-1-1572
	11. N° de contrat — ASC ou Transports Canada OSD81-00186

12. Nom et adresse de l'organisme parrain		13. Genre de rapport et période visée
Centre de développement des transports(CDT) 1000 o., rue Sherbrooke Montréal, Québec H3A 2R3	CN Rail Research 935 o., rue de LaGauchetière Mtl, Qué H3C 3N4	avr. 1/82 - mars 31/83
		14. Code de l'organisme parrain CDT 4567

15. Remarques additionnelles	16. Agent de projet — CDT
	D.W. Dibble

17. Résumé

Ce rapport décrit les travaux exécutés en vertu du contrat CN/CDT no. OSD81-00186 pendant la période du 1er avril 1982 au 31 mars 1983. Il traite notamment des travaux de recherche en cours tant en laboratoire que sur voie visant à améliorer les caracteristics des traverses en béton; à développer une technique de calcul permettant de déterminer l'épaisseur optimale de la couche granulaire d'une voie ferrée; à développer les techniques améliorées afin de régler le réchauffage de longs rails soudés; à développer un prototype à mesurer le module à partir d'une voiture d'auscultation en mouvement; et à améliorer le graissage du rail.

18. Mots-clés	19. Diffusion
Recherche et développement, rail, interaction dynamique train/voie ferrée, ballast, sous-couche, voie ferrée, traverses en béton, contraintes, fixations	Disponibilité d'exemplaires en nombre limité au CDT

20. Classification de sécurité (de ce rapport)	21. Classification de sécurité (de cette page)	22. Nombre de pages	23. Prix
non-classifié	non-classifiée		--

CDT TDC 79-005

The contents of this report reflect the views of the contractor and not necessarily the official views or policies of the Transportation Development Centre of Transport Canada.

Acknowledgments

CN Rail Research gratefully acknowledges the assistance and support of the Transportation Development Centre of Transport Canada and the Department of Supply and Services.

This research could not have been carried out to the extent achieved without the financial assistance of the Federal Government under Contract OSD-81-00186.

FOREWORD

This final report of the Phase IX program of research on track structure represents a significant stage in a much longer term research effort designed to provide optimum design and materials parameters for current and future track needs for Canadian railroads, leading to an improved understanding of the cost/benefit relationships of various designs, both for track construction, maintenance, and safety of operations.

In view of the projected expansion of railroad operations in the next decade, the information developed by such programs will form an important part of future railroad technology.

TABLE OF CONTENTS

	Page
1. INTRODUCTION	1
2. OBJECTIVES OF WORK	3
3. RESEARCH PROGRESS	8
4. EXPECTED BENEFITS OF TRACK/TRAIN DYNAMICS RESEARCH	11
5. CONCLUSIONS	12
Appendix A	
Publications pertaining to Phase IX	13
Appendix B	
Progress reports to Transport Canada Transportation Development Centre	14

LIST OF FIGURES

Figure 1	Measurement of Dynamic Gauge Widening in Softwood Tie on a 6° Curve Mile 16.5, Albreda Subdivision, October 1982
Figure 2	Laboratory Fatigue Test Set-up for Evaluation of Concrete Tie Rail Fastening Systems

1. INTRODUCTION

This document constitutes the final summary report on Contract 0SD-81-00186 representing the 9th phase of a continuing program of track/train dynamics research. The first phase of the program was carried out on behalf of the former Transportation Development Agency under Contract 97004, and the second, fourth, fifth, sixth, seventh and eighth phases under Department of Supply and Services contracts 0ST-5-0002, 0ST-76-00084, 0ST-77-09013, 0SD-78-00031, 0SD-78-00097, 0SD-79-00126 and 0SD-81-00005 respectively on behalf of the Transportation Development Centre of Transport Canada.

This Phase IX report includes a general summary of all work completed under Appendix A, Work Statement of Contract 0SD-81-00186 dated April 1, 1982 and covering the period 1 April 1982 to 31 March 1983 and specifically the following general areas of research:

1. To continue laboratory evaluation of the CN-60B tie characteristics under a number of parameters.
2. To continue laboratory evaluation of pads and insulators for concrete ties under a number of parameters with the view to developing appropriate specifications.
3. To continue laboratory evaluation of promising new materials and modifications of concrete ties such as steel fibre surfaced concrete, etc.
4. To determine the natural bending frequencies of various forms of concrete ties with the view to determining tie damping characteristics.
5. To continue track loading and deflection measurement under a number of parameters.

6. To continue the development of a set of design curves for selection of sub-ballast thickness based upon field measurements, laboratory soil tests and computer models.

7. To investigate the maintenance of continuous welded rail (CWR) under a number of parameters.

8. To continue work on the design, development and evaluation of a prototype system for the continuous measurement of track modulus from a moving vehicle.

9. To investigate the advantages of improved types of rail lubricators in reducing rail wear.

The research carried out under this program is co-ordinated with the Association of American Railroads (AAR)-managed International Track/Train Dynamics program through an industry-government steering committee, on which Transport Canada is represented by the Transportation Development Centre (TDC). The work is in no respect a duplication of research carried out in the United States, but rather is complementary to the U.S. program. Finally, the report includes a discussion of both the long and short term benefits of the program and concludes with suggestions for future work in a continuing TDC/CN effort.

2. OBJECTIVES OF THE WORK

The over-all objective of the program was to increase the knowledge of track/train dynamics and track structure in order to meet present and future traffic needs. The objectives of the current work were to establish specifications and guidelines for the purpose of improving the performance of certain track components, including the performance characteristics of concrete ties; to develop an effective and efficient method for determining optimum subballast thickness; to develop improved techniques for controlling thermal effects in continuous welded rail; to develop a prototype system for continuous measurement of track modulus; and to improve utilization of rail lubrication.

Specifically, the following were the objectives of the various research tasks in Phase IX:

Task 1 - Concrete Ties

Laboratory Evaluation of CN60B Tie Characteristics

i) to determine static bending strength in 4 modes of bending (rail seat + ve and -ve, tie centre + ve and -ve).

ii) to determine first crack, structural crack, and ultimate failure loads and moments.

iii) to determine relationship between tie bending moment and concrete strain.

Laboratory Evaluation of Pads and Insulators

i) to determine through inclined loading laboratory fatigue tests, relative service life of various tie pads and insulators.

ii) to define performance requirements in terms of material physical properties.

Improved Concrete

i) to conduct laboratory tests to determine static and fatigue bending strengths of the six CN60B ties manufactured by Genstar Costain using steel fibre-reinforced concrete and compare results with regular CN60B ties.

Natural Bending Frequencies of Ties

i) to determine the natural frequencies of the first three resonant bending modes for each of the CN60A, CN60B, and fibre-reinforced CN60B ties.

ii) to determine tie damping characteristics.

Track Loading and Deflection Measurements

i) to continue centre bending deflection measurements on CN60A ties.

ii) to take bending deflection measurements on newly installed CN60B ties.

iii) to define concrete tie loading environment, high frequency (possibly up to 2 kHz) measurements of wheel loads and tie bending strains. Documentation of rail movements with respect to tie for evaluation of fatigue life requirements of pads, insulators, and rail clips.

Task 2 - Subballast Thickness Study

Laboratory Experimentation (McGill Geotechnical Research Centre

i) to complete dynamic triaxial tests on frozen and thawed Joliette soils.

ii) to conduct soil creep tests in an effort to find correlation with triaxial tests.

iii) to utilize computer programs in an effort to correlate laboratory test data with field measured data (validation of roadbed design criteria).

Field Test

i) to continue measurement of track settlements at Edmonton and Joliette (from Spring thaw till Fall).

Task 3 - Maintenance of Continuous Welded Rail (CWR)

i) to use electronic distance measurement (EDM) equipment to monitor variation of rail "stress-free" temperatures in rails laid during 1981.

ii) to use EDM equipment to measure effectiveness of rail heating system to be used in 1982.

iii) to define requirements for a new improved rail heating system to be developed for the 1983 rail laying season.

Force Variations in CWR

i) to undertake an experiment on a new test site that would lend itself better to frequent observation of track structure behaviour under traffic and thermal loading.

ii) to use data logging equipment to monitor the variation of rail force over closely spaced time intervals, so as to better document the behaviour of CWR under conditions of varying thermal and mechanical loading.

iii) to continue laboratory evaluations and field endurance tests of new types of rail mounted transducers showing promise of being an acceptable solution for this particular application.

Measurement of Absolute Longitudinal Force Level

i) to conduct feasibility study on instrumentation that makes use of the fact that natural frequency of transverse vibration of rail is directly influenced by a force applied along its longitudinal axis.

ii) to investigate in the laboratory the high frequency response of longitudinally loaded rail in an effort to find some method of correlating instrumentation output with rail force level.

iii) to verify accuracy of measurement system on track tests.

iv) to develop a rail longitudinal force measurement system suitable for use by track maintenance engineers.

v) to investigate the feasibility of using the blind hole drilling technique as an interim means of determining rail force levels on a limited basis.

Task 4 - Vertical Track Modulus

Prototype Development

i) to continue from Phase 8 contract, the selection of a suitable measurement vehicle, the design, construction, and calibration of a prototype system for the continuous measurement of vertical track modulus from a moving vehicle.

Task 5 - Rail Wear in connection with Rail Lubricators

Field Testing

i) to install improved rail lubricators on at least two curves in the Montreal Area.

ii) to measure rail wear on two curves in the Montreal area.

iii) to observe spread of lubrication grease along track.

iv) to determine optimum grease delivery rates and optimum lubricator spacing along track.

3. RESEARCH PROGRESS

Task 1 - Concrete Tie Research

Intensive laboratory evaluation of the CN60B tie was carried out. Data from a series of laboratory tie binding tests on strain gauged ties were analyzed and a preliminary report was written on the relationships between tie bending moment and concrete strain. This report was forwarded to Canadian and British tie manufacturers for comment; design criteria for concrete ties may be altered somewhat as a result of these tests. Fatigue tests were carried out on a number of pads and insulators and by the end of the contract, the test work had been documented in preparation for writing a report.

Work was progressed on reinforced concrete for ties, involving CN60B ties using steel fibre-reinforced concrete. By the end of the contract, fatigue test work on these ties was completed and data were being analyzed.

Track loading and deflection measurements were carried out at field test sites on the Albreda and Clearwater Subdivisions in British Columbia. By the end of the contract, dynamic gauge widening and strain measurements were being analyzed and documented.

Task 2 - Subballast Thickness Study

Track settlement measurements at test sites at the Edmonton and Montreal areas were taken on a regular basis throughout the term of the contract. All of the 1981-1982 CN field measurement data were documented and the report was nearing completion. The McGill Geotechnical Research Centre continued their soils creep and dynamic tri-axial tests and although McGill was not able to complete their laboratory, documentation and report writing prior to expiry of the present contract, it is expected that this work will be completed as quickly as possible.

Task 3 - Maintenance of Continuous Welded Rail (CWR)

Work continued on the use of electronic distance measurement (EDM) equipment to monitor variation of rail "stress-free" temperatures in rails laid in 1981. Rails laid at Port Hope, Ontario, in 1981 were remeasured to determine if any length changes have occurred over the 1981-1982 winter. In addition, new EDM measurements were taken on eight rail strings at Garry, Ontario. All data were gathered and analyzed in preparation for writing of the report.

The work on force variations in CWR was continued. A new technique for setting up extensometer measurement stations on rail was developed and used to prepare four strings of CWR prior to laying. These were installed at Garry, Ontario. At the same time, rail creepage and shifting of track structure was followed closely.

Sets of readings taken at Garry were analyzed, but there was considerable scatter of data and it was obvious that work was necessary to improve the reading accuracy of instrumentation for future measurements.

Research into measurement of absolute longtitudinal force level in rail was continued and work was progressed on the development of a suitable rail loading frame and instrumentation requirements. Theoretical work was carried out on the propagation of flexural waves in rail. The quasi-static transverse compliance of the rail, while under the action of axial forces was also investigated and by the end of the contract, these theoretical rail vibration response analyses were basically completed in preparation for actual measurements on rail.

Task 4 - Vertical Track Modulus

During the previous Phase VIII program, work was continued on the analysis of the sensitivity to track geometry of various instrument configurations envisaged for measuring modulus from a moving vehicle and a report prepared on the measurement of static track modulus was completed. However, no further work was possible in this area during the current contract because of the heavy workload on other tasks.

Task 5 - Rail Wear in connection with Rail Lubricators

A test site was installed at the west entrance to CN's Taschereau Yard in Montreal and several sets of measurements were taken to determine non-lubricated wear rates on rail. These were entered into the computer and metal loss on non-lubricated rail accurately determined. At the end of the contract,preparations were underway to determine wear rates on lubricated rail. At the same time, a considerable amount of work was carried out in the laboratory on pumping tests of various rail lubricator greases at various temperatures. A new grease was placed in a rail lubricator at Taschereau Yard and rail measurements were being continued.

4. EXPECTED BENEFITS OF TRACK/TRAIN DYNAMICS RESEARCH

As outlined in previous phases, the Canadian and joint TDC/AAR International Programs on track/train dynamics continue to provide benefits in the short term and offer extensive benefits in the longer term.

Work on track structure and components, such as concrete ties and rail fastenings, will continue to provide benefits in terms of minimizing costs of track installation and maintenance, reducing loss of track capacity due to maintenance and increasing safety of operations.

In addition, projected developments in double tracking and new line construction, particularly in Western Canada, occasioned by estimated large increases in movements of resource and agricultural traffic in the 80's, will benefit from such research.

In short, the benefits of continuing track/train dynamics research far outweigh the resources expended for this research.

5. Conclusions

Research in the area of track/train dynamics, particularly as it related to track structure, should be continued as such research offers the potential for reducing costs and promoting safety of rail operations.

The following is a list of specific areas requiring research and represents continuing research of work carried out in Phase IX and earlier phases of the joint TDC/CN program:

a) Research on Concrete Ties

b) Laying and Maintenance of Continuously Welded Rail (CWR)

Appendix A

PUBLICATIONS PERTAINING TO PHASE IX TRACK/TRAIN DYNAMICS PROGRAM

1. 1981-82 Research on Concrete Railroad Ties

2. Predicting Requirements for Subballast Thickness-Progress Report No.3

3. Laboratory Investigation of Long Term Railroad Track Subgrade Settlement due to Cyclic Loading

4. Design Requirements for Railroad Track Subballast Thickness-Summary Report

5. Use of Rail Heaters in Laying of Continuous Welded Rail

6. Evaluation of Techniques for Monitoring Thermal Stresses in Long Welded Rail - Report No.2

7. Measurement of Absolute Longitudinal Rail Forces - Feasibility Study

8. Measurement of Track Modulus from a Moving Vehicle - Feasibility Study

9. Evaluation of Rail Lubricators

10. Strength and Stability of Ballast System

(All reports in preparation - not yet published)

Figure 1
Measurement of Dynamic Gauge Widening-Softwood Ties on 6° Curve, Mile 16.5, Albreda Sub. October 1982

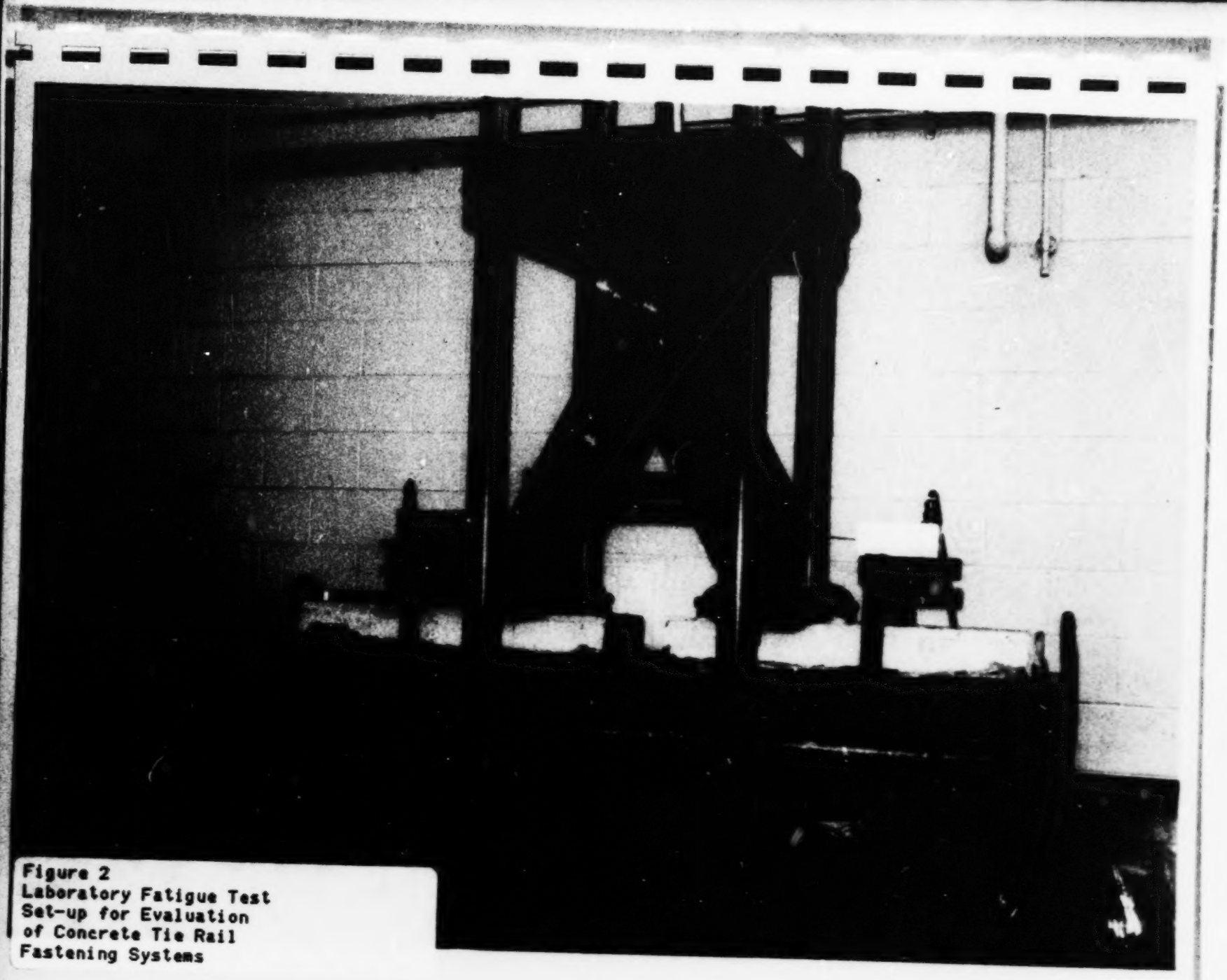

Figure 2
Laboratory Fatigue Test
Set-up for Evaluation
of Concrete Tie Rail
Fastening Systems

Appendix B

Progress Reports to the Transport Canada Transportation Development Centre

Progress Report No.1

April - May 1982

Co-operative CN/Transport Canada
Development Centre Track/Train
Dynamics Program - Phase 9

Contract Serial No.
OSD 81 00186

PROGRESS REPORT TO TDC

TRACK/TRAIN DYNAMICS PROGRAM PHASE 9

Period April - May 1982

TASK 1 - CONCRETE TIE RESEARCH

(a) Fatigue life evaluation of pads and insulators was halted in order that the hydraulic system could be used for a non-TDC test. Testing will be resumed as soon as the system becomes available.

(b) Laboratory physical property tests were conducted on two new pads for concrete ties.

(c) A series of tie bending tests on a strain gauged tie were completed, these to develop the relationships between concrete strain and tie bending moment.

TASK 2 - PREDICTING REQUIREMENTS FOR SUBBALLAST THICKNESS

(a) Track settlements were measured on a weekly basis at the five Edmonton area sites and the two Joliette sites during this period.

(b) McGill Geotechnical Research Centre conducted soils creep and dynamic triaxial tests. The McGill Phase 8 Report was undergoing rewrite, and will be presented to CN in draft form the first week of June.

(c) The last week in May was spent in writing on the Phase 8 report on 1981 field measurements. About 2 weeks work are required before the report will be ready for typing.

TASK 3 - MAINTENANCE OF CONTINUOUS WELDED RAIL (CWR)

(a) RAIL HEATING AHEAD OF THE RAIL CHANGE OUT (RCO) MACHINE

Rail which had been measured with Electronic Distance Measurement (EDM) equipment last fall at Port Hope, Ontario, was remeasured the third week in April in order to determine if any length changes had occurred over the winter. Rail destressing operations were conducted at two selected locations.

New EDM measurements were taken on 8 rail strings laid by the RCO in April and May at Garry, Ontario.

(b) FORCE VARIATIONS IN CWR

There has been considerable activity on this task during the present reporting period. A new technique for setting-up extensometer measurement stations on rail has been developed and used, to prepare four strings of CWR prior to laying. These have now been installed, on the North and South tracks at Garry, near Lancaster, Ontario. Stations are located on 50 and 100 ft. intervals, along both rails of each track. In all, there are 74 stations, which are being closely monitored. Rail creepage and shifting of track structure components will also be followed closely.

Some further developments will be necessary in the areas of instrumentation and data processing, to speed up data collection and presentation of results, since we intend to investigate axial rail forces far more intensively at this site than was the case in the previous CWR experiment at Brighton.

(c) MEASUREMENT OF ABSOLUTE LONGITUDINAL FORCE LEVEL

Preliminary design has started on a loading frame to be used in our experimental investigation of relationships between transverse vibratory response and axial force in rail. Further theoretical work has also been done on the propagation of shear and flexural waves in the rail.

TASK 4 - VERTICAL TRACK MODULUS

Because of urgency of tasks involving CWR and the 1982 rail laying program, little progress was made on the modulus task during this period.

TASK 5 - RAIL WEAR IN CONNECTION WITH RAIL LUBRICATORS

Special splice bars for positioning the rail wear measurement device were located on three spots on the high rail and one spot on the low rail of the curve at Ballantyne (west entrance to Taschereau Yard). Two sets of wear measurements have been taken on nonlubricated rail. Work was also done on a wheel counter to record traffic. A lubricator will be installed at the west end of the curve when the nonlubricated rail wear rate has been satisfactorily established.

OTHER

Final editing was completed on CN Reports No. 165, 174 and 175 and they were sent to reproduction. Draft copy of CN Report No. 176 was completed and sent to TDC.

Shear box tests were run and are continuing on ballast samples in order to finalize work on the Phase 8 Ballast Strength task.

PROGRESS REPORT NO.2

June - July 1982

Co-operative CN/Transport Canada
Development Centre Track/Train
Dynamics Program - Phase 9

Contract Serial No.
OSD 81 00186

PROGRESS REPORT TO TDC

TRACK/TRAIN DYNAMICS PROGRAM PHASE 9

Period June - July 1982

TASK 1 - CONCRETE TIE RESEARCH

(a) Data from a series of laboratory tie bending tests on two strain gauged ties were analyzed and a preliminary report was written on the relationships between tie bending moment and concrete strain. This report has been forwarded to Canadian and British tie manufacturers for comment.

(b) Static bending tests were completed and fatigue bending tests were commenced on the CN60B concrete tie. Static bending tests were also commenced on the fibre-reinforced concrete ties.

(c) Preliminary plans for field measurements on concrete ties were drawn up and an inspection trip will be made to the Mountain Region in mid-August to locate suitable test measurement sites.

TASK 2 - PREDICTING REQUIREMENTS FOR SUBBALLAST THICKNESS

(a) Problems were encountered with the gauges being used for track settlement measurements in Edmonton and a trip was made to remedy the situation. Settlement readings are being taken every week or so.

(b) Some writing was done on the Phase 8 Report covering 1981 dynamic field measurements.

TASK 3 - MAINTENANCE OF CONTINUOUS WELDED RAIL (CWR)

(a) Rail Heating Ahead of the Rail Change Out (RCO) Machine

All rail temperature measurements taken during rail laying operations in the spring have been analyzed and plans are progressing in co-operation with the Engineering Department for the development of an improved rail heating system for use in 1983.

(b) Force Variations in CWR

The sets of readings taken from the 74 extensometer stations at Garry, Ontario, have been analyzed. There was considerable scatter in the data and work is in progress to improve the reading accuracy for future measurements.

(c) Measurement of Absolute Longitudinal Force Level

Work was progressed on the development of a suitable rail loading frame and instrumentation requirements.

TASK 4 - VERTICAL TRACK MODULUS

Work is progressing slowly on this task because of heavy work load on other tasks and non-TDC-funded projects.

TASK 5 - RAIL WEAR IN CONNECTION WITH RAIL LUBRICATORS

Rail wear measurements taken on the curve at Ballantyne have been analyzed and there was insufficient data to establish gauge face wear rates. Readings will be continued on the unlubricated rail until satisfactory wear rates are determined and then the effects of rail lubrication will be evaluated.

PROGRESS REPORT NO. 3

August-September 1982

Co-operative CN/Transport Canada
Development Centre Track/Train
Dynamics Program - Phase 9

Contract Serial No.
OSD-81-00186

PROGRESS REPORT TO TDC

TRACK/TRAIN DYNAMICS PROGRAM PHASE 9

PERIOD AUGUST - SEPTEMBER 1982

TASK 1 - CONCRETE TIE RESEARCH

a) Concrete tie moment strains were analyzed and compared to similar type measurements taken in the U.K. Design criteria for concrete ties may be altered somewhat as a result of these tests.

b) Fatigue bending tests have been completed on the CN60B tie and fatigue tests will commence shortly on the fibre-reinforced ties.

c) An inspection trip was made to Mountain Region in mid-August and a comprehensive set of field measurements is scheduled for the week of October 4.

TASK 2 - PREDICTING REQUIREMENTS FOR SUBBALLAST THICKNESS

Track settlement measurements in Edmonton and Montreal areas were taken on regular basis throughout this period.

TASK 3 - MAINTENANCE OF CONTINUOUSLY WELDED RAIL (CWR)

a) Rail Heating Ahead of the RCO Machine

Discussions were held with Engineering Department.

b) Force Variations in CWR

Very little time has been devoted to this task, despite the very real need for higher instrument accuracy which has been made clearly evident by the test results obtained so far at Garry. This shortfall in work effort is due to the fact that the principal researcher on this task was on holidays in the earlier part of August and has since been assigned to a different high-priority project.

c) Measurement of Absolute Longitudinal Force Level

Further theoretical work has been carried out on the propagation of flexural waves in the rail. The quasi-static transverse compliance of the rail, while under the action of axial forces, has also been investigated. This is the property which one would determine in the limiting case of a swept-frequency vibratory response test as the excitation frequency approaches DC.

TASK 4 - VERTICAL TRACK MODULUS

No work has been carried out on this task because of heavy work load on other tasks.

TASK 5 - RAIL WEAR IN CONNECTION WITH RAIL LUBRICATORS

Rail wear measurements were taken on the curve at Ballantyne. These have been entered in the computer and metal loss has been accurately determined.

Progress Report No.4

October-November 1982

Co-operative CN/Transport Canada
Development Centre Track/Train
Dynamics Program - Phase 9

Contract Serial No.
OSD 81 00186

PROGRESS REPORT TO TDC

TRACK/TRAIN DYNAMICS PROGRAM PHASE 9

Period October - November 1982

TASK 1 - CONCRETE TIE RESEARCH

(a) Results from the concrete tie moment-strain tests were documented, final conclusions and recommendations have yet to be drawn up.

(b) A series of fatigue bending tests were run and are continuing on the fibre-reinforced CN60B ties.

(c) Dynamic gauge widening and strain measurements were taken on CN60A and CN60B ties on curves on the Albreda and Clearwater Subdivisions in British Columbia during the week of October 4, 1982. Some of this information has been analyzed and documented.

TASK 2 - PREDICTING REQUIREMENTS FOR SUBBALLAST THICKNESS

Final sets of track settlement readings were taken at the test sites near Edmonton and Joliette. Results have now all been plotted and writing of final report covering CN 1981 and 1982 field measurements will commence during first week of December.

TASK 3 - MAINTENANCE OF CONTINUOUSLY WELDED RAIL (CWR)

(a) Rail Heating Ahead of the RCO Machine

A decision was made to defer work on development on a new improved rail heating system. Discussions were held with Engineering on how to improve the existing rail heating system for the 1983 season.

(b) Force Variations in CWR

No work was done on this sub-task because of necessary commitment of personnel to another high priority project.

(c) Measurement of Absolute Longitudinal Force Level

Theoretical vibration response analyses were continued in preparation for laboratory testing which is expected to get underway within the next reporting period.

TASK 4 - VERTICAL TRACK MODULUS

No work was done on this project because of necessary reallocation of personnel.

TASK 5 - RAIL WEAR IN CONNECTION WITH RAIL LUBRICATORS

Two sets of rail wear readings were taken on the curve at Ballantyne in an effort to establish non-lubricated wear rates. Lubrication will be commenced as soon as the non-lubricated wear rate has been documented.

PROGRESS REPORT NO.5

December 1982-January 1983

Co-operative CN/Transport Canada
Development Centre Track/Train
Dynamics Program - Phase 9

Contract Serial No.
OSD-81-00186

PROGRESS REPORT TO TDC

TRACK/TRAIN DYNAMICS PROGRAM PHASE 9

Period December 1982 - January 1983

TASK 1 - CONCRETE TIE RESEARCH

(a) Most of the fatigue test work on the fiber-reinforced ties has now been completed.

(b) Results from all of the fatigue test work on pads and insulators has been documented in preparation for report writing.

(c) Preliminary analysis of dynamic gauge widening and concrete tie strain measurements taken on the Mountain Region during October 1982 has been completed and statistics on tie bending strains are now being developed.

TASK 2 - PREDICTING REQUIREMENTS FOR SUBBALLAST THICKNESS

All of the 1981-82 CN field measurement data has now been documented and about 75% of the report writing has been completed. A meeting with McGill Geotechnical Research Centre has been scheduled for February 8 and a comprehensive review will be made of all the field measurement and laboratory test data. CN is not planning any further field measurements at this time, and this project has not been included in the Phase X contract proposal. It is now felt that McGill will not be able to complete their laboratory work, documentation, and report writing prior to expiry of the present contract, and some form of sub-contract extension will have to be made in order to bring this project to a successful conclusion. This will be discussed with TDC sometime after the meeting with McGill.

TASK 3 - MAINTENANCE OF CONTINUOUSLY WELDED RAIL (CWR)

(a) Rail Heating Ahead of the RCO Machine

Work has been started in gathering together the measurement data taken in 1982 in preparation for writing of report.

(b) Force Variation in CWR

No work was done on this sub-task because of necessary commitment of personnel to another high priority project.

(c) Measurement of Absolute Longitudinal Force Level

Theoretical rail vibration response analyses were basically completed and measurements on rail are about to get underway.

TASK 4 - VERTICAL TRACK MODULUS

No work was done on this project because of necessary reallocation of personnel.

TASK 5 - RAIL WEAR IN CONNECTION WITH RAIL LUBRICATORS

A considerable amount of work has been done in laboratory pumping tests of various rail lubricator greases at various temperatures. A new grease has been placed in a rail lubricator in Taschereau Yard and rail wear measurements are being continued.

PROGRESS REPORT NO.6

February - March 1983

Co-operative CN/Transport Canada
Development Centre Track/Train
Dynamics Program - Phase 9

Contract Serial No.
OSD-81-00186

PROGRESS REPORT TO TDC

TRACK/TRAIN DYNAMICS PROGRAM PHASE 9

Period February - March 1983

TASK 1 - CONCRETE TIE RESEARCH

(a) A preliminary report on the fatigue test work on fiber-reinforced ties has been written. It has been concluded that steel fibers did not significantly improve either the static or fatigue bending strength of ties, although the resistance to impact breakage was improved. While a few more fatigue tests remain to be done in order to complete the investigation, no further research on fiber-reinforced concrete is contemplated at this time.

(b) Strain gauge measurements were taken on four concrete ties before and after saw-cutting in order to determine pre-stress wire bond development length. The technique was successful and 3 more ties will be strain gauged and saw-cut within the next two weeks.

(c) Statistical analysis of concrete tie bending strains measured on the Mountain Region in October 1982 has been completed. The statistics were not strong enough to define the concrete tie safety factors and more measurements will be taken out west in May or June.

(d) A start was made on writing a report to cover all work on concrete ties conducted over the last 2 years.

TASK 2 - PREDICTING REQUIREMENTS FOR SUBBALLAST THICKNESS

(a) Writing of large formal report covering the final CN field measurement data has been completed, and draft copy will be sent to TDC within a week.

(b) A lengthy meeting was held with McGill Geotechnical Research Centre on 8 February, and work required for completion of study was outlined.

(c) A work statement covering proposed work has been sent to TDC.

(d) Two reports will be issued in late 1983 - early 1984 for completion of this study, one report documenting in detail the McGill laboratory work, and one close-out report summarizing the entire 4-1/2 year study.

TASK 3 - MAINTENANCE OF CONTINUOUSLY WELDED RAIL (CWR)

(a) Rail Heating Ahead of the RCO Machine

Measurements taken in 1982 have been documented in preparation for report writing. Discussions were held with Engineering Department concerning development and possible application of diesel-fired heaters with rail temperature feedback control system on the RCO. Because of very heavy workloads, CN Research is serving only as consultant at present.

(b) Force Variation in CWR

No work was done on this sub-task on account of necessary commitment of personnel to another high priority project.

(c) Measurement of Absolute Longitudinal Force Level

A report is being prepared covering some of the theoretical investigative work. Laboratory testing on rail section is expected to be underway by mid-May.

TASK 4 - VERTICAL TRACK MODULUS

No work was done on this project because of necessary reallocation of personnel. CN Engineering and Research both still very interested in project because it is felt measurement of track modulus could be very important for allocation of maintenance and capital funds for upgrading of existing lines.

TASK 5 - RAIL WEAR IN CONNECTION WITH RAIL LUBRICATORS

Rail on the measurement curve at Ballantyne was replaced, and rail wear reference plates were removed from old rail and reapplied on new rail. Measurements are continuing. Considerable work was also conducted on measurement of lubricator grease pumping rates both in the laboratory and in the field.

FORMAL REPORTING UNDER PHASE 9 CONTRACT

A great deal of work has been accomplished under the Phase 9 Contract, but there has been difficulty in finding time for formal report preparation. Following is list of reports to be issued and current status.

1. 1981-82 Research on Concrete Railroad Ties

   - Report now being written.

2. Predicting Requirements for Subballast Thickness
   Progress Report No. 3

   - Draft copy of report completed.

3. Laboratory Investigation of Long Term Railroad Track Subgrade Settlement Due to Cyclic Loading

   - Will not be issued until late 1983 (McGill Geotechnical Centre).

4. Design Requirements for Railroad Track Subballast Thickness Summary Report

   - Will not be issued until early 1984 (CN Research).

5. Use of Rail Heaters in Laying of Continuous Welded Rail

   - Will be written following completion of No. 1 above.

6. Evaluation of Techniques for Monitoring Thermal Stresses in Long Welded Rail Report No. 2

   - Deferred indefinitely on account of reallocation of personnel.

7. Measurement of Absolute Longitudinal Rail Forces - Feasibility Study

   - Report should be ready in draft form by mid-May.

8. Measurement of Track Modulus from a Moving Vehicle - Feasibility Study

   - Deferred indefinitely on account of reallocation of personnel.

9. Evaluation of Rail Lubricators

   - Much data accumulated, have not started report preparation.

10. Strength and Stability of Ballast System

    - Laboratory testing 90% completed, no start yet made on report preparation.

POOR

QUALITY

ORIGINAL